Appendix C

Supplemental Air Information

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Contents

List of Acronyms

BCG	Biota Concentration Guide
CFR	Code of Federal Regulations
DCG	derived concentration guidelines
DOE	U.S. Department of Energy
FCP	Fernald Closure Project
IEMP	Integrated Environmental Monitoring Plan
NESHAP	National Emissions Standards for Hazardous Air Pollutants
RCS	Radon Control System
TLD	thermoluminescent dosimeter

List of Measurement Abbreviations

cm	centimeters
m^3	cubic meters
°C	degrees Celsius
°F	degrees Fahrenheit
km	kilometer
kph	kilometers per hour
µCi	microCuries
µCi/hr	microCuries per hour
µCi/mL	microCuries per milliliter
$\mu g/m^3$	micrograms per cubic meter
mph	miles per hour
mCi	milliCuries
mrem	millirem
mSv	milliSievert
pCi/m^3	picoCuries per cubic meter
pCi/L	picoCuries per liter
yr	year

Appendix C presents additional air monitoring data and analysis in support of Chapter 5 of this 2007 Site Environmental Report. This appendix consists of five attachments as follows:

- Attachment C.1 provides the results of the radiological air particulate monitoring program, including an assessment of 2007 results with respect to historical data and concentration versus time plots of the total uranium and total particulate.
- Attachment C.2 provides the results of the radon monitoring program, including an assessment of radon data relative to continuous radon monitors. This discussion focuses on the U.S. Department of Energy (DOE) standards contained in DOE Order 5400.5, proposed 10 CFR 834, and an evaluation of trends observed in the 2007 data.
- Attachment C.3 provides information on the direct radiation monitoring program, including an assessment of 2007 results with respect to historical data.
- Attachment C.4 provides a summary of the meteorological data measured at the Butler County Airport during 2007, and historical wind speed and directional data collect at the Fernald Preserve.
- Attachment C.5 provides the results of supplemental dose assessments that are part of the standards and requirements contained in DOE Order 5400.5. The methods and data sources used for the population and biota dose assessments are explained. In addition, an evaluation of trends observed in the dose assessments over the past nine years is also provided.

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Attachment C.1

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C.1.0 Radiological Air Particulate

In 2007, the Fernald Preserve operated 6 air monitoring stations (Figure C.1−1) as part of the Integrated Environmental Monitoring Plan (IEMP) Radiological Air Particulate Monitoring Program. Data from five boundary monitoring stations and one background monitoring station are used to demonstrate compliance with the National Emissions Standards for Hazardous Air Pollutants (NESHAP) Subpart H. Previous site environmental reports (SERs) collected data from several project-specific monitors and 16 site boundary locations to evaluate the release of contaminants via active remediation and construction projects. In 2006, soil remediation activities ended and the final cells of the on-site disposal facility (OSDF) were capped. Therefore, monitoring was discontinued at six of the 16 site boundary stations in April 2006 (IEMP variance V/FCN R4B-04), at the WPTH-2 location in August 2006 (IEMP variance V/FCN R4B-08), and at five of 16 site boundary locations in December 2006 (IEMP variance V/FCN R4B-12).

Table C.1−1 provides an operational summary for the IEMP air monitoring stations in 2007. Most instruments operated nearly 100 percent of the time, with the worst performance being 96.3 percent at AMS-24. Although the stations are shut down for about five minutes when the filters are changed, this does not accumulate a sufficient amount of time to account for down time in the calculation. Therefore, some monitors show nearly 100 percent operational time. Periodic electrical outages and equipment malfunctions created short periods of down-time that result in operation times of less than 100 percent.

Table C1−1. Operational Summary for Air Particulate Monitoring Stations

Location	Number of Samples	Sample Start Date	Last Sample Collection Date	Operating Time (hours)	Percent of Operation
Boundary					
AMS-2	12	02-Jan-07	02-Jan-08	8661	98.9
AMS-3	12	02-Jan-07	02-Jan-08	8634	98.6
AMS-6	12	02-Jan-07	02-Jan-08	8497	97.0
AMS-8A	12	02-Jan-07	02-Jan-08	8597	98.1
AMS-24	12	02-Jan-07	02-Jan-08	8433	96.3
Background					
AMS-12	12	02-Jan-07	02-Jan-08	8643	98.7

C.1.1 Particulate Monitoring Results

Air filters were exchanged in each instrument every month and analyzed for total uranium and total particulate. Monthly thorium sampling was discontinued at the end of 2006 because soil remediation and construction activities were completed in October 2006. Tables C.1−2 (uranium) and C.1−3 (particulate) summarize minimum, maximum and average values for 2007 and 2006 at each location and also minimum and maximum values over the 1990 to 2007 time period. Relative to the 2006 results, uranium and particulate concentrations decreased in 2007, which reflects the completion of soil remediation in 2006 and transition to legacy management activities.

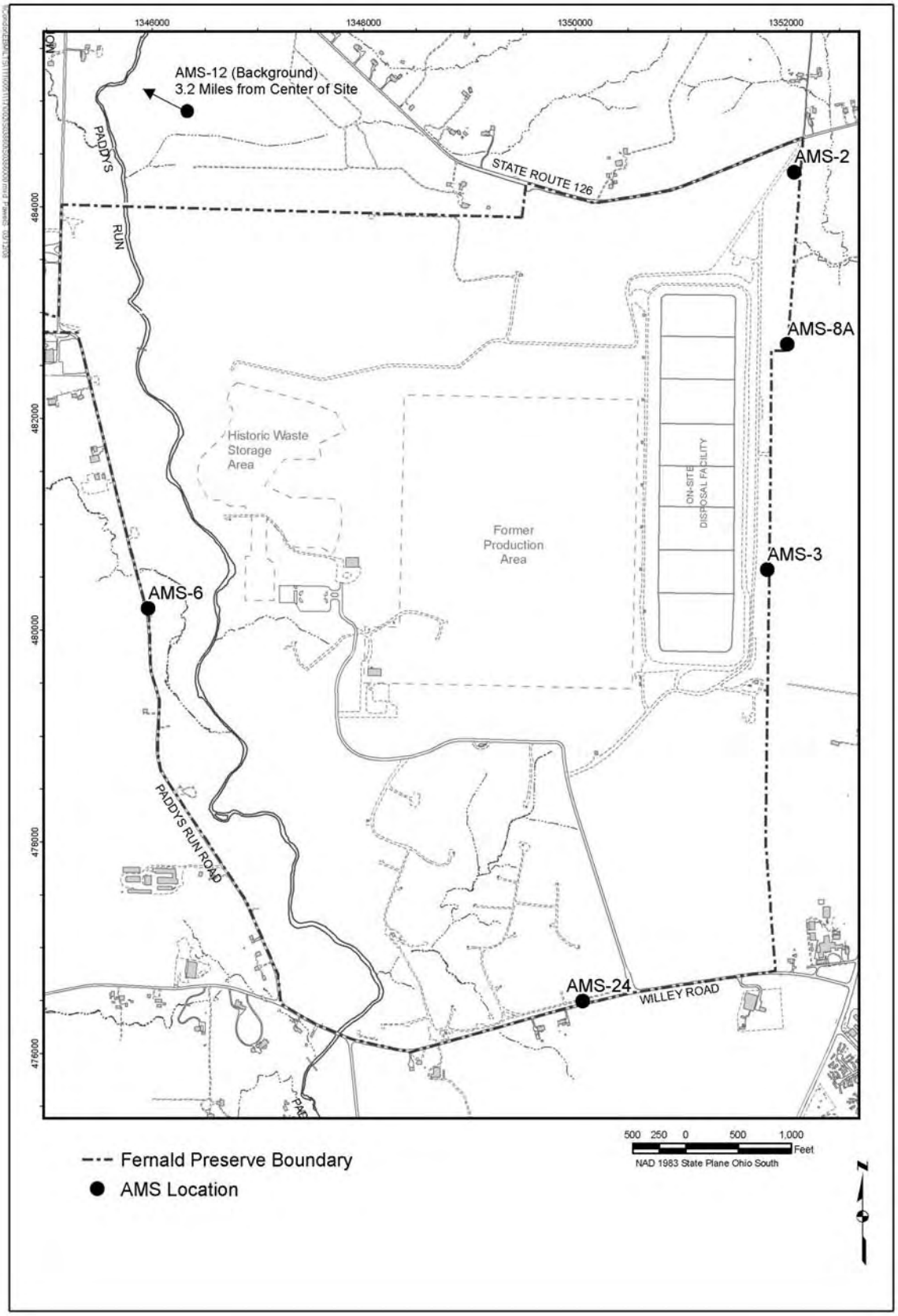

Figure C.1–1. IEMP Air Monitoring Locations

Table C.1−2. Total Uranium Concentration in Air Particulate[a]

	2007 RESULTS pCi/m^3 x 1E-06				2006 RESULTS pCi/m^3 x 1E-06				1990 through 2007 pCi/m^3 x 1E-06	
Location	Number of Samples	minimum	maximum	average	Number of Samples	minimum	maximum	average	minimum	maximum
Boundary										
AMS-2	12	11 ± 0.41	24 ± 0.43	15 ± 0.15	27	1.7	83	28	0.0	9060
AMS-3	12	6.0 ± 0.92	41 ± 1.31	18 ± 0.21	27	2.7	260	83	0.0	17000
AMS-6	12	9.2 ± 1.4	20 ± 0.75	16 ± 0.21	27	1.2	53	23	0.0	3200
AMS-8A	12	10 ± 0.42	54 ± 2.5	18 ± 0.29	27	1.5	110	35	0.0	2100
AMS-24	12	7.7 ± 0.34	26 ± 1.5	14 ± 0.18	27	1.6	57	30	0.0	200
Background										
AMS-12	12	7.3 ± 1.08	18 ± 0.77	13 ± 0.17	27	0.78	23	11	0.0	480

[a]Monthly samples (total U activity calculated assuming natural isotopic distribution) in 2007 versus biweekly samples in previous years.
± = analytical uncertainty for 2007 result

Table C.1−3. Total Particulate Concentrations in Air[a]

	2007 RESULTS ug/m^3				2006 RESULTS ug/m^3				1990 through 2007 ug/m^3	
Location	Number of Samples	minimum	maximum	average	Number of Samples	minimum	maximum	average	minimum	maximum
Boundary										
AMS-2	12	1.2	39	21	27	0.0	50	30	1.2	77
AMS-3	12	1.7	46	25	27	20	110	56	1.7	160
AMS-6	12	1.5	42	26	27	0.0	39	27	1.5	62
AMS-8A	12	1.3	46	23	27	11	53	30	1.3	89
AMS-24	12	1.2	32	19	27	16	61	38	1.2	110
Background										
AMS-12	12	1.0	36	23	27	14	67	25	6.0	4100

[a]monthly samples in 2007 versus biweekly samples in previous years.

Figures C.1−2 through C.1−7 summarize the total uranium and total particulate for each location. In general, uranium and particulate exceed the background measurement most frequently at the eastern boundary monitors (AMS-2, AMS-3 and AMS-8A), as the prevailing winds blow from southwest to northeast across the site. However, Figure C.1−8 shows that the mean and 95 percent confidence interval for monthly uranium and particulate data collected at the boundary monitors are not significantly different than the mean at the background location. This conclusion is consistent with the results of the soil certification process, which show that the uranium concentration in the site soil has been returned to background, or very near background, across the site.

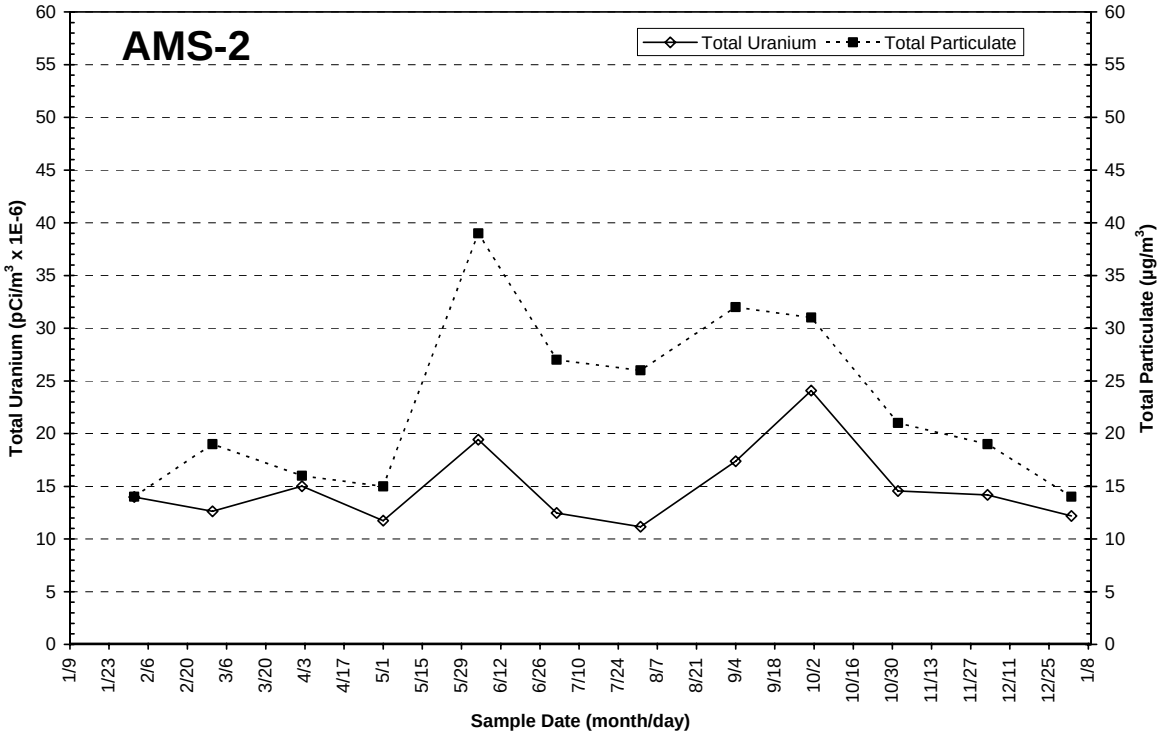

Figure C.1−2. 2007 Uranium and Particulate Concentrations in Air

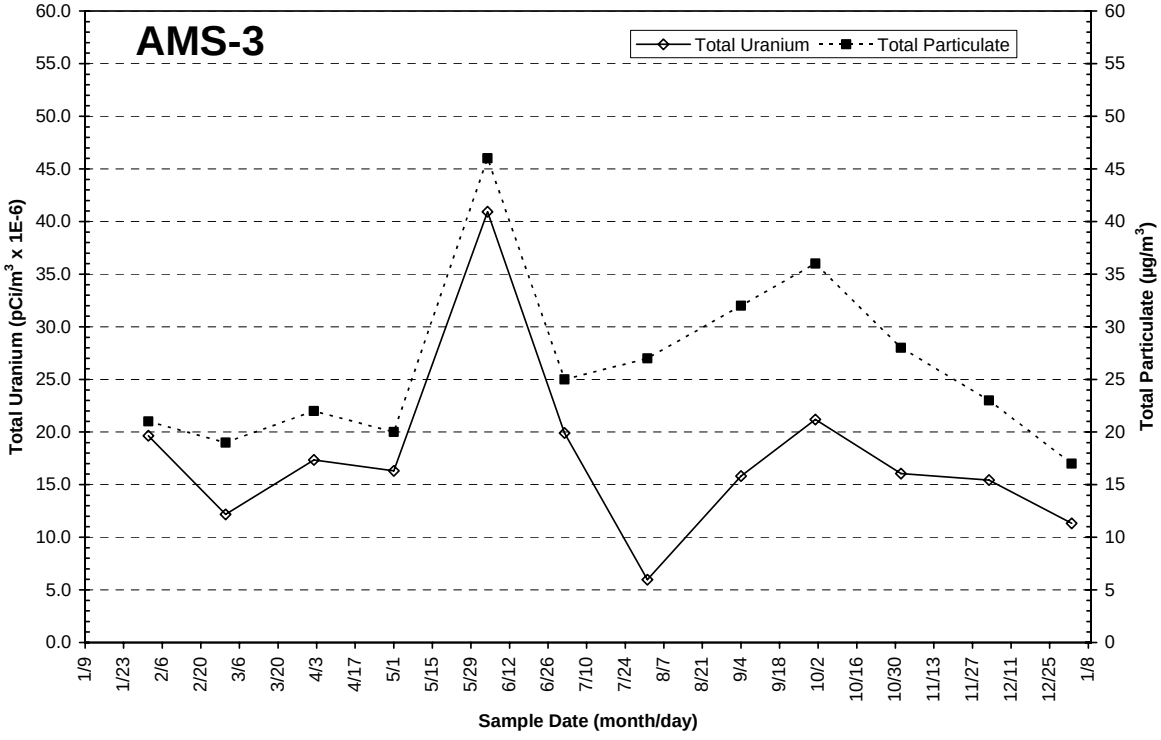

Figure C.1−3. 2007 Uranium and Particulate Concentrations in Air

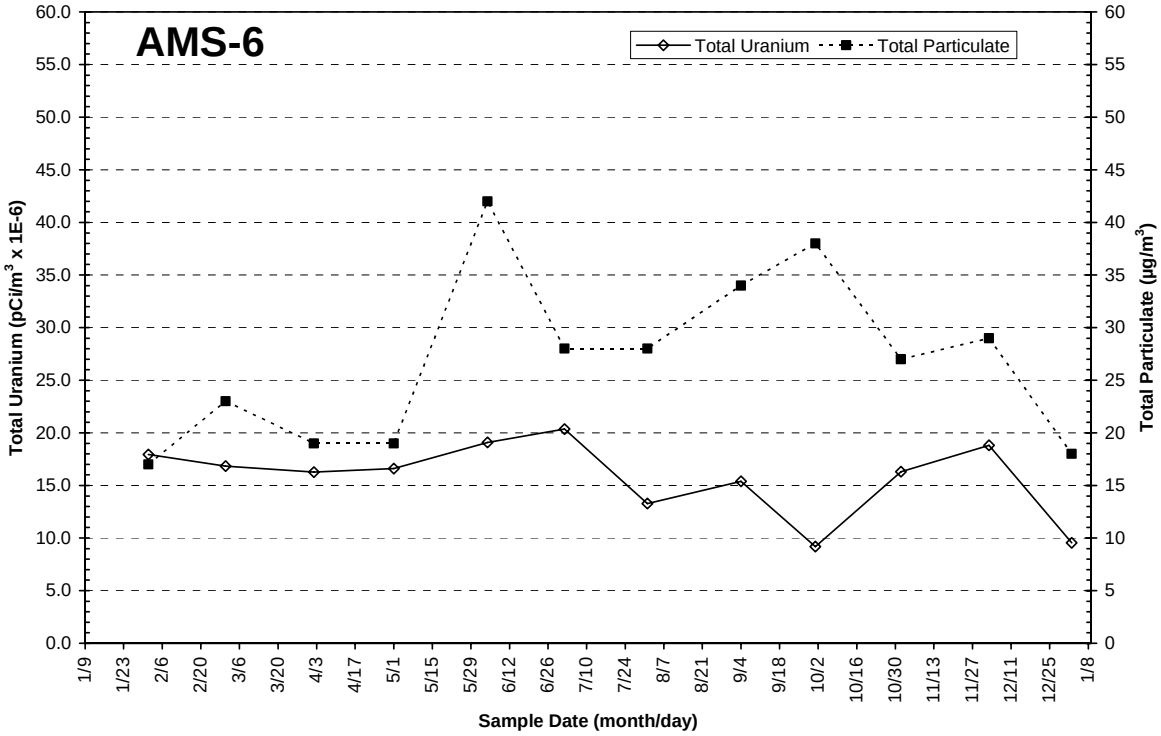

Figure C.1−4. 2007 Uranium and Particulate Concentrations in Air

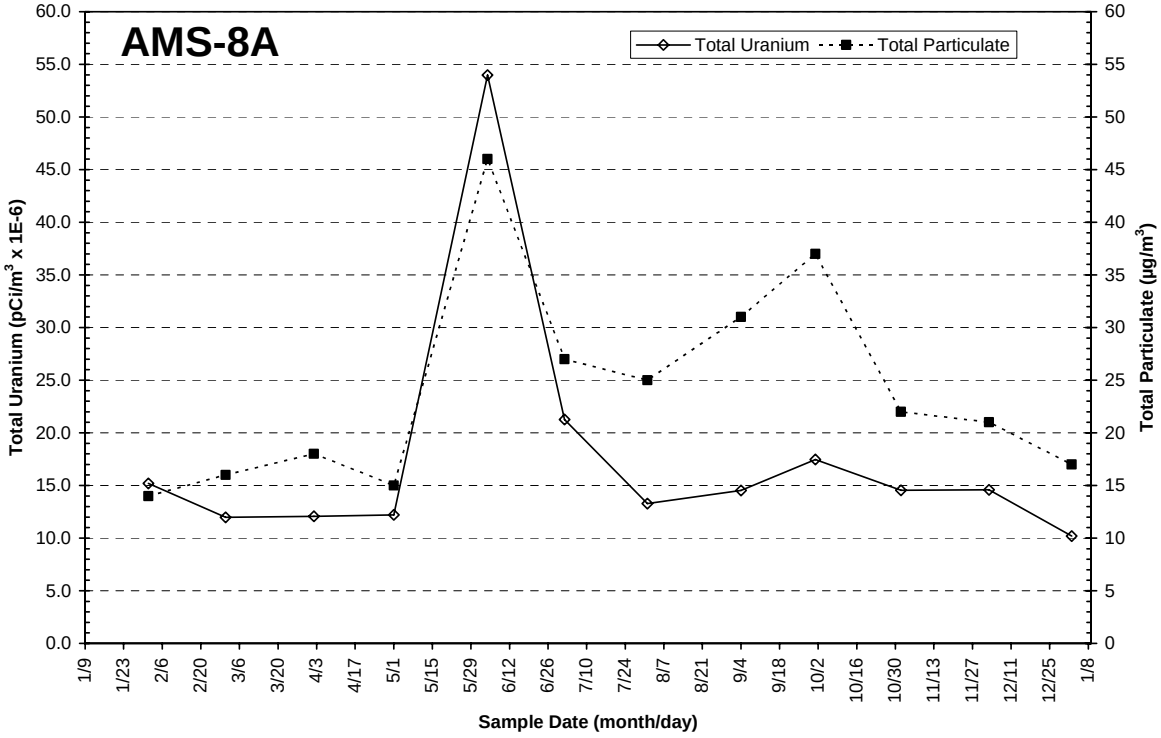

Figure C.1−5. 2007 Uranium and Particulate Concentrations in Air

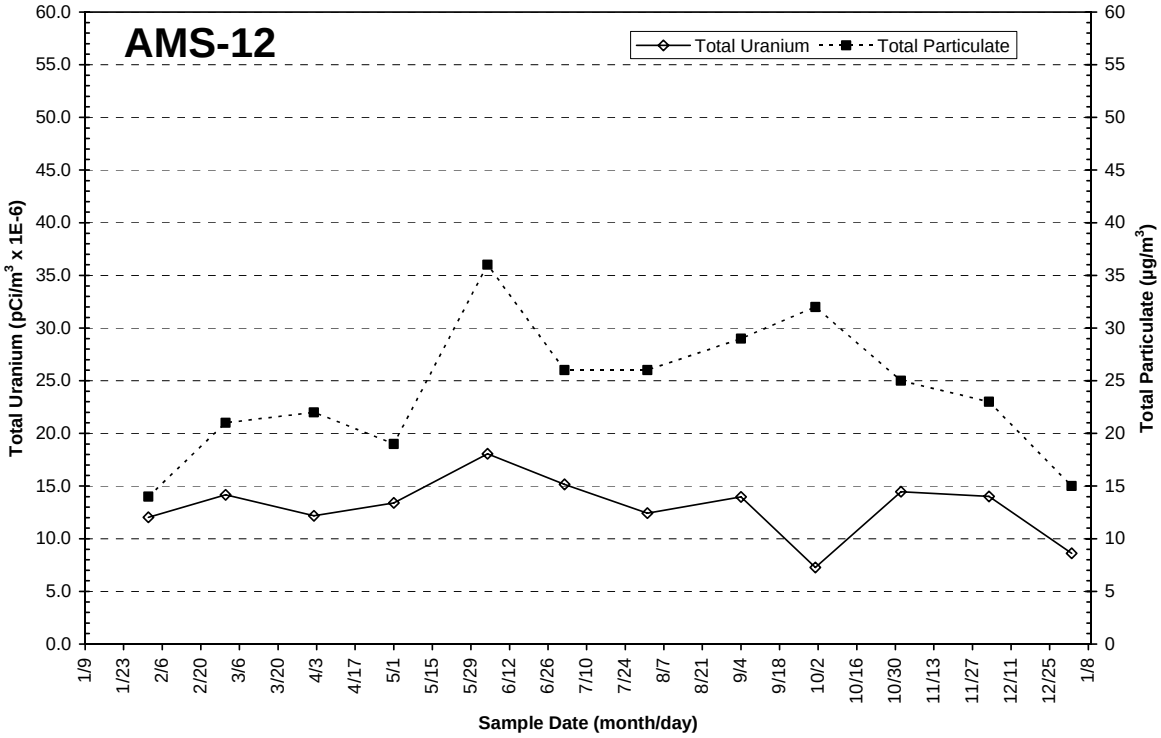

Figure C.1−6. 2007 Uranium and Particulate Concentrations in Air

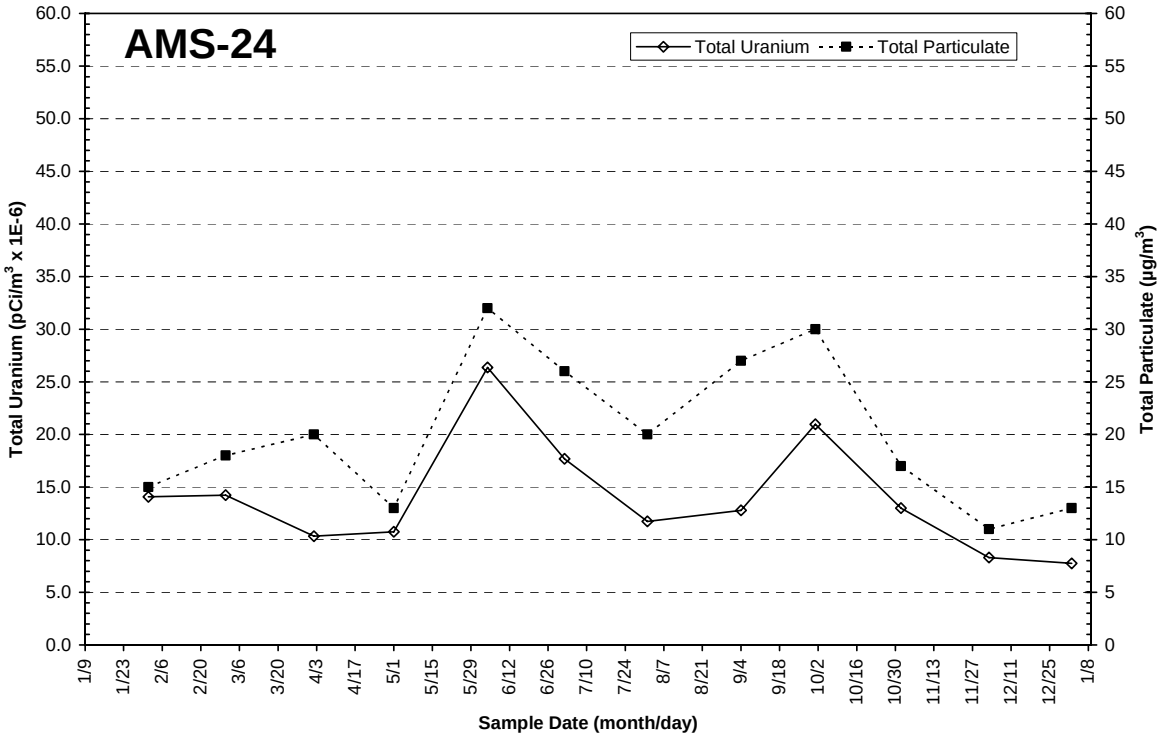

Figure C.1−7. 2007 Uranium and Particulate Concentrations in Air

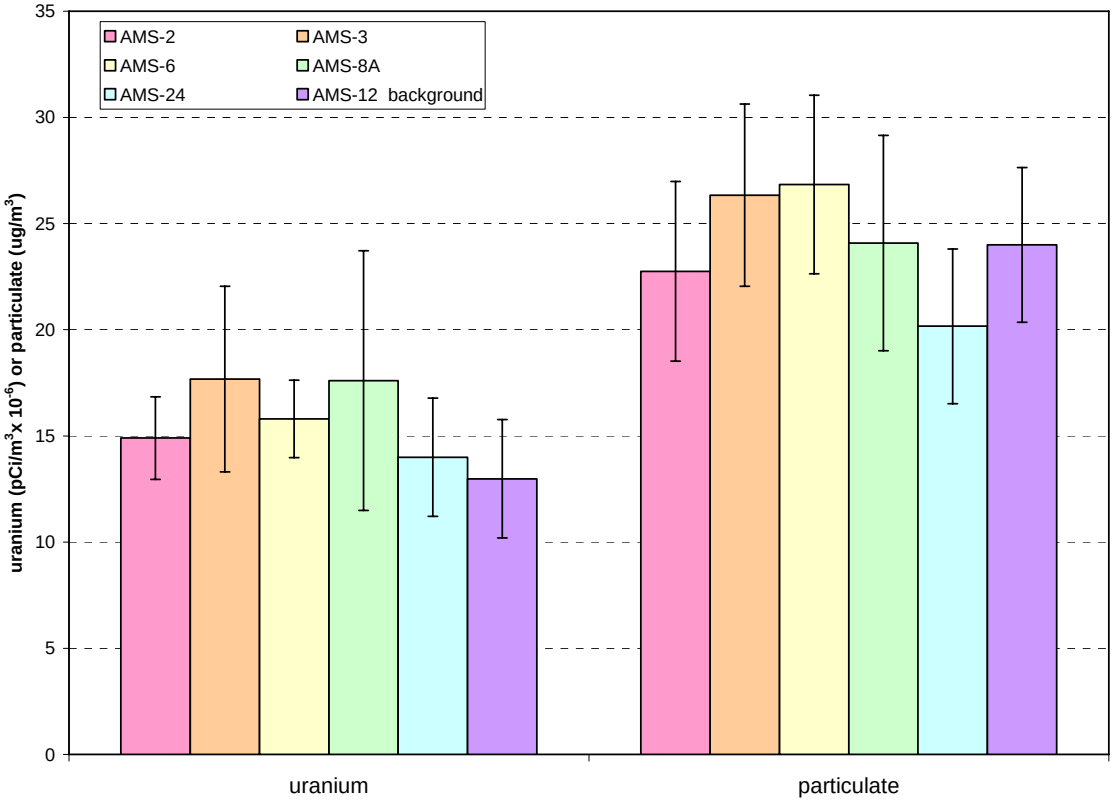

Figure C.1−8. 2007 Comparison of Means for Air Data

C.1.2 Evaluation of Isotopic Data from Airborne Emissions

Quarterly composites of the monthly samples were analyzed for the isotopes of uranium (234, 235 and 238), thorium (228 and 232) and radium (226) to evaluate compliance with NESHAP requirements (Appendix D). Average values and uncertainties (Table C.1−4) indicate the isotope activities in the particulate collected at the site boundary are similar to those collected at the background location. A plot of the mean and 95 percent confidence interval (Figure C.1−9) for the quarterly results indicates there is not a significant difference between the boundary and background monitors. However, the large confidence interval for some Ra-226 results reflects a large standard deviation at some locations, and it is unknown if this is an analytical problem or true variation at the location. When the analytical measurement uncertainty and confidence interval are taken into consideration, the locations have essentially the same result, which indicates the remediation of soil was effective in lowering contamination to near background levels.

Table C.1−4. 2007 Average Radionuclide Concentrations in Air Particulate[ab]

Location		Concentration (pCi/m^3) U-234	U-235	U-238	Th-228	Th-230	Th-232	Ra-226	Total Activity
Boundary									
AMS-2		9.56E-07	0.00E+00	9.04E-07	1.14E-06	7.33E-07	4.89E-07	5.14E-06	9.36E-06
	±	2.04E-07	na	2.03E-07	2.40E-07	1.71E-07	1.38E-07	9.73E-07	1.07E-06
AMS-3		1.14E-06	0.00E+00	9.49E-07	8.78E-07	1.14E-06	6.00E-07	9.56E-06	1.43E-05
	±	2.09E-07	na	1.87E-07	2.03E-07	2.37E-07	1.57E-07	1.53E-06	1.59E-06
AMS-6		9.04E-07	0.00E+00	9.53E-07	1.16E-06	8.33E-07	5.76E-07	1.16E-05	1.61E-05
	±	1.75E-07	na	1.81E-07	2.17E-07	1.71E-07	1.40E-07	1.79E-06	1.83E-06
AMS-8A		1.46E-06	0.00E+00	1.48E-06	1.08E-06	7.53E-07	4.74E-07	6.82E-06	1.21E-05
	±	2.44E-07	na	2.49E-07	2.09E-07	1.66E-07	1.34E-07	1.33E-06	1.41E-06
AMS-24		9.90E-07	5.53E-08	9.74E-07	6.87E-07	9.75E-07	6.17E-07	1.61E-05	2.04E-05
	±	2.05E-07	5.49E-08	2.03E-07	2.06E-07	2.31E-07	1.76E-07	2.61E-06	2.65E-06
Sum for Boundary Monitors									
		5.46E-06	5.53E-08	5.26E-06	4.93E-06	4.43E-06	2.76E-06	4.93E-05	7.22E-05
	±	4.66E-07	5.49E-08	4.61E-07	4.82E-07	4.42E-07	3.35E-07	3.88E-06	4.00E-06
Background									
AMS-12		9.00964E-07	0.00E+00	8.82792E-07	9.60E-07	9.79E-07	5.78E-07	8.91E-06	1.32E-05
	±	2.04E-07	na	1.94E-07	2.12E-07	2.08E-07	1.51E-07	1.47E-06	1.53E-06

Isotope Percent

	U-234	U-235	U-238	Th-228	Th-230	Th-232	Ra-226	Total
boundary[c]	7.56	0.08	7.29	6.83	6.14	3.82	68.3	100
±	0.77	0.08	0.76	0.77	0.70	0.51	6.57	
background	6.82	0.00	6.68	7.27	7.41	4.37	67.4	100
±	1.74	0.00	1.66	1.81	1.80	1.25	13.6	

[a]A concentration of 0.0 indicates the filter results were equal to or less than the blank results.
[b]Average obtained by summing the active of four quarters and dividing by total air volume through the monitor.
[c]Represents the sum of all boundary monitors.
± = 2 sigma error propagated from reported quarterly errors.

On an elemental basis, the boundary data (represented by the sum of all monitors for each element) show the total activity to be distributed as 15 percent uranium, 17 percent thorium and 68 percent radium (Table C.1−4). The 2007 background activities (AMS-12) are distributed as 14 percent uranium, 19 percent thorium and 67 percent radium. Similarity in the boundary and background are expected if remediation has returned isotopic values to near background levels.

Data in Table C.1−4 are also used for the NESHAP calculations presented in Appendix D. The NESHAP calculations evaluate the dose contribution in excess of background for radium, thorium and uranium isotopes. A summary of the elemental distribution of dose at each boundary monitor is provided on Figure C.1−10. As a percentage, the majority of the dose is attributed to radium at AMS-3, AMS-6 and AMS-24, thorium at AMS-2 and uranium at AMS-8A. Note that 95 percent of the dose at AMS-24 is attributed to radium isotopes, but this is 95 percent of a very small dose (0.023 mrem/yr, which is well below the NESHAP limit of 10 mrem/yr above background, see Appendix D).

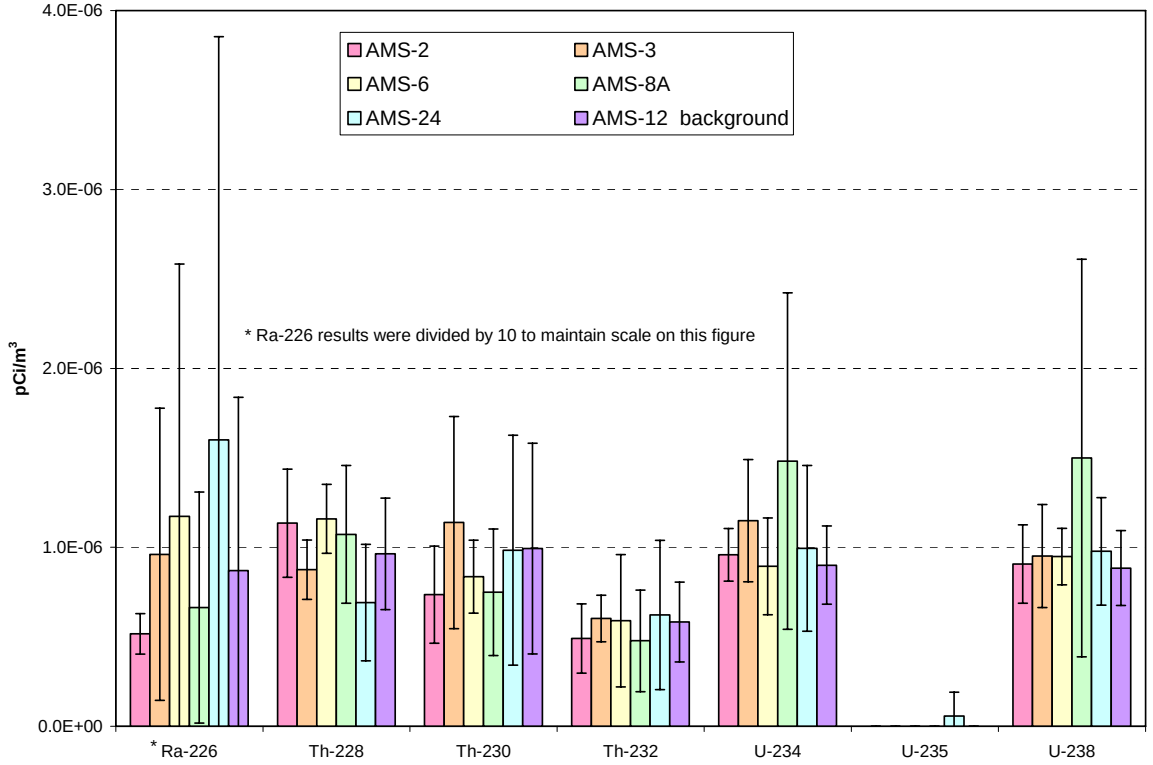

Figure C.1−9. 2007 Comparison of Means for NESHAP Data

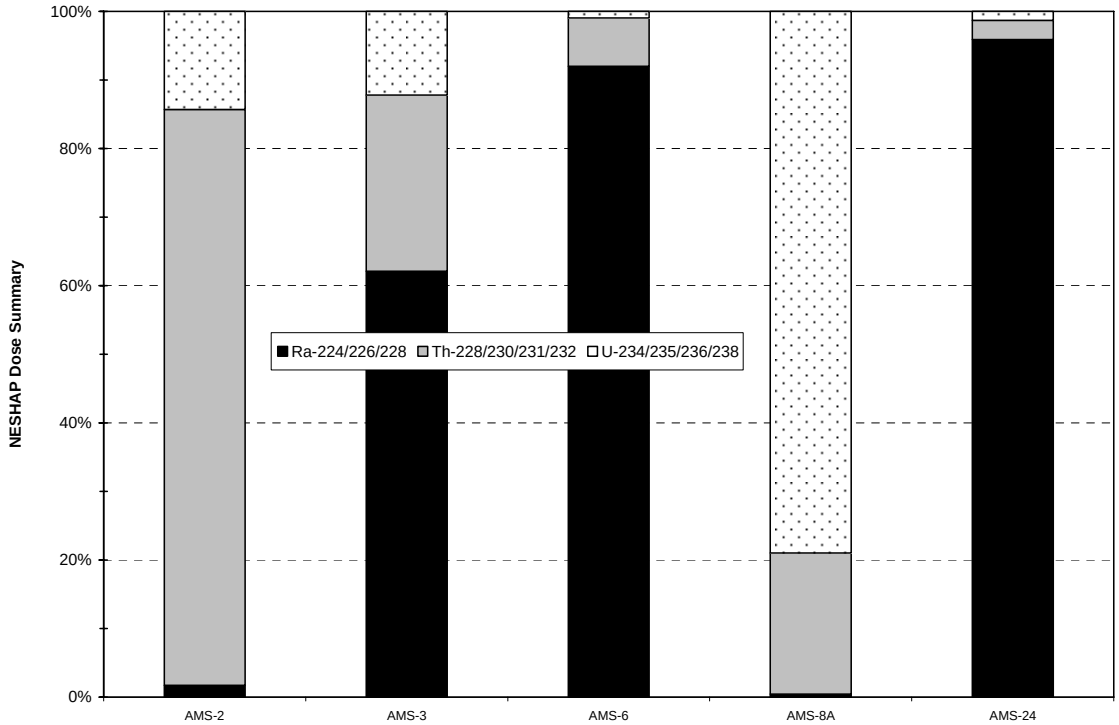

Figure C.1−10 2007 Isotopic Dose Contributions at AMS Locations

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Attachment C.2

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C.2.0 Radon

The Fernald Preserve radon monitoring program was reduced to five boundary monitors and one background monitor in 2007 (Figure C.2−1), as radon emissions associated with the silos treatment facilities ceased in 2006 and there is no longer a significant surface source for radon on the site. Radon data collected under the program are compared to the radon concentration standards contained in DOE Order 5400.5 (DOE 1993) and proposed 10 CFR 834. The pertinent standards and associated 2007 compliance status are as follows:

The proposed 10 Code of Federal Regulations (CFR) 834 annual average limit at and beyond the facility boundary is 0.5 picoCuries per liter (pCi/L) above background; there were no exceedances in 2007.

The DOE annual average limit within the site is 30 pCi/L above background. As expected, this limit was not exceeded in 2007 because significant surface sources for radon no longer exist at the Fernald Preserve.

The DOE limit measured at any point over the facility is 100 pCi/L above background. As expected, this limit was not exceeded in 2007 because significant surface sources for radon no longer exist at the Fernald Preserve.

Continuous monitors used at the Fernald Preserve boundary track daily changes in the radon levels and determine compliance with the noted standards. In 2007, the radon monitors at the site boundary operated greater than 96 percent of the time. The down-time was associated with downloading instrument data, interruptions due to extremely cold temperatures, power interruptions, and/or an increase in routine maintenance. Table C.2−1 provides a summary of the minimum, maximum and average radon concentrations for 2007 and 2006.

Figure C.2−2 shows the net annual average radon concentration recorded at each location. All locations show background corrected radon values that are below the 10 CFR 834 proposed limit of 0.5 pCi/L above background. Boundary monitors AMS-3 and AMS-24 are the only locations that exceed the annual average background radon concentration (0.2 and 0.1 pCi/L, respectively).

Figures C.2−3 through C.2−7 summarize the monthly average reading for each boundary monitor. Note that the instrument reports hourly radon values to the nearest 0.1 pCi/L, but no uncertainty is given on the data log.

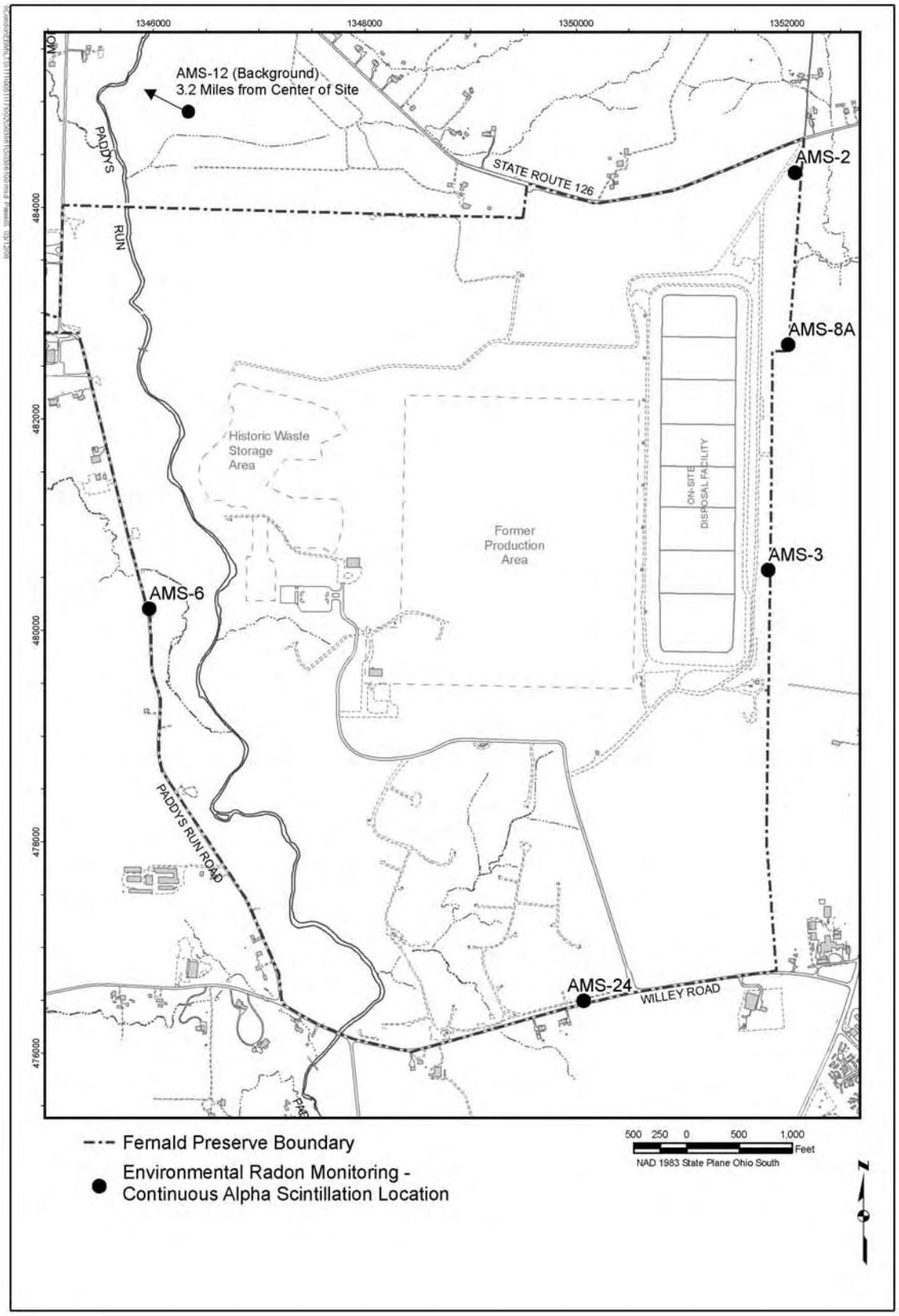

Figure C.2–1. Radon Monitoring Locations

Table C.2−1. Continuous Radon Monitors[a]

Location	2007 RESULTS (pCi/L) Minimum	Maximum	Average	2006 RESULTS (pCi/L) Minimum	Maximum	Average
Boundary						
AMS-2	0.2	0.7	0.3	0.2	0.8	0.5
AMS-3	0.2	0.8	0.5	0.2	0.6	0.4
AMS-6	0.2	0.7	0.3	0.3	1.1	0.6
AMS-8A	0.2	0.7	0.3	0.2	0.7	0.4
AMS-24	0.3	0.8	0.4	0.2	0.9	0.6
Background						
AMS-12	0.2	0.5	0.3	0.1	0.5	0.3

[a]monthy averages used to calculate annual minimum, maximum and average

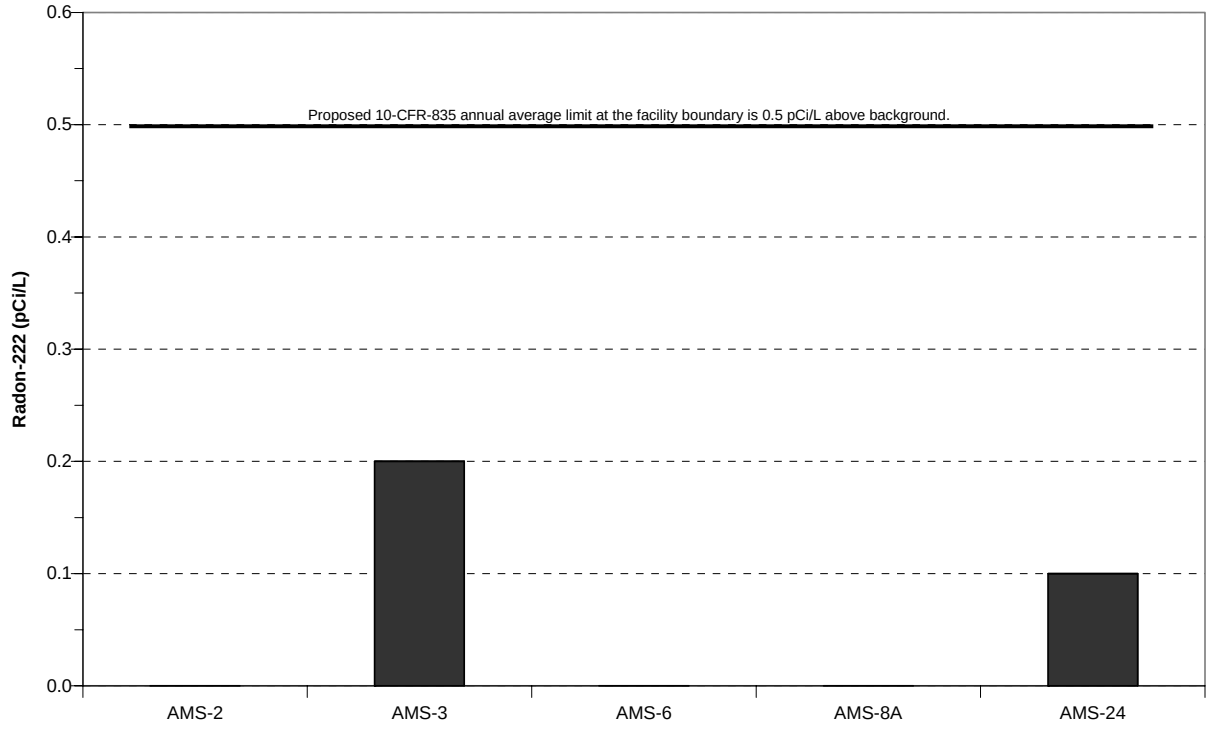

Figure C.2−2 2007 Net Annual Average Concentration for Each Facility Boundary Monitor

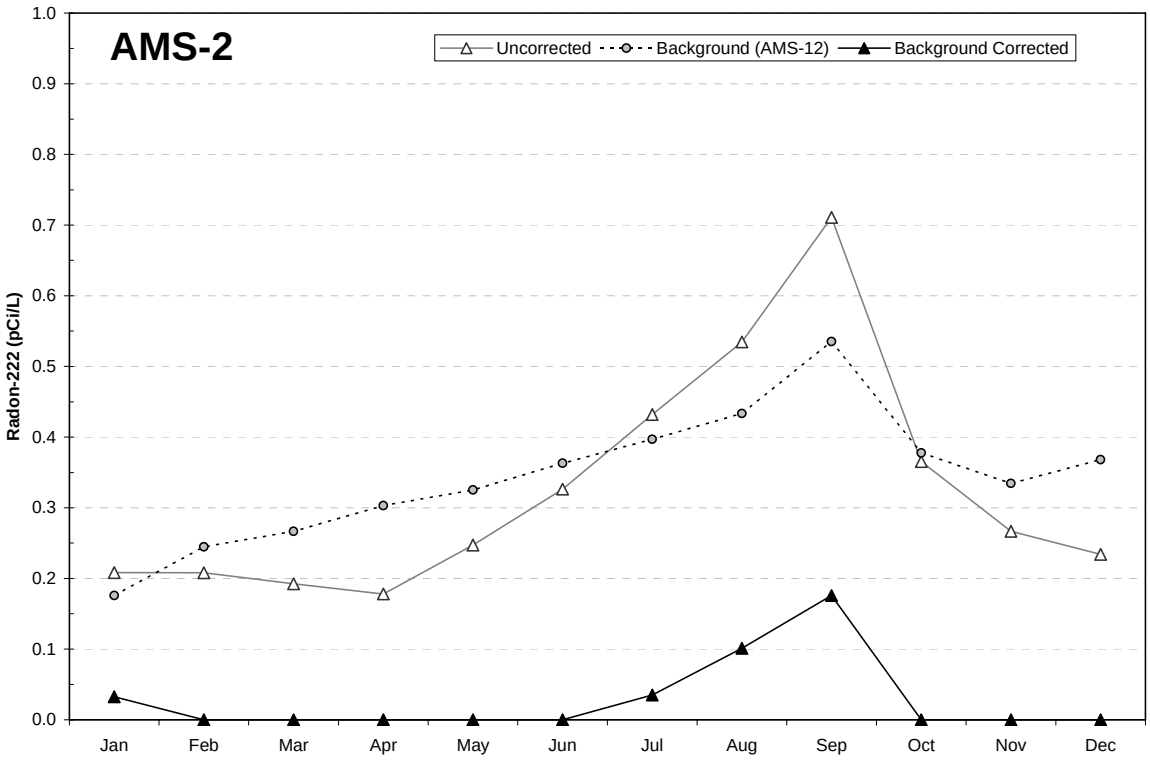

Figure C.2−3 2007 Monthly Average Concentration for Facility Boundary

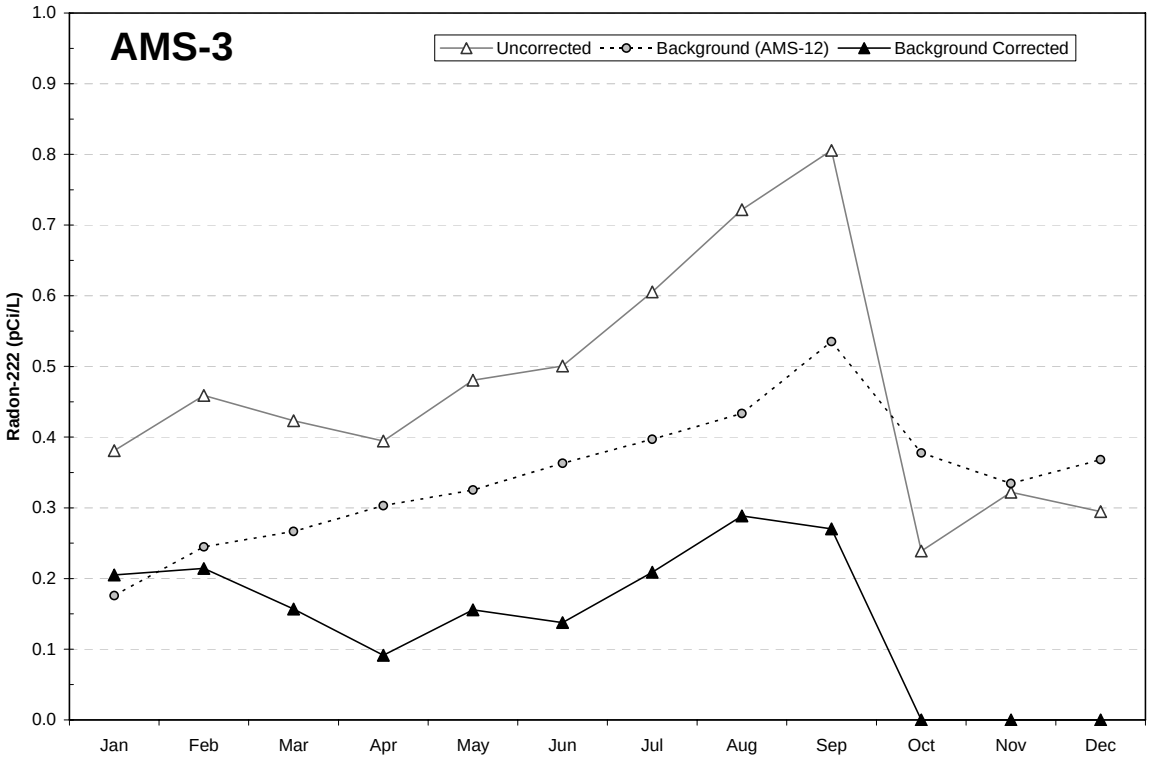

Figure C.2−4 2007 Monthly Average Concentration for Facility Boundary

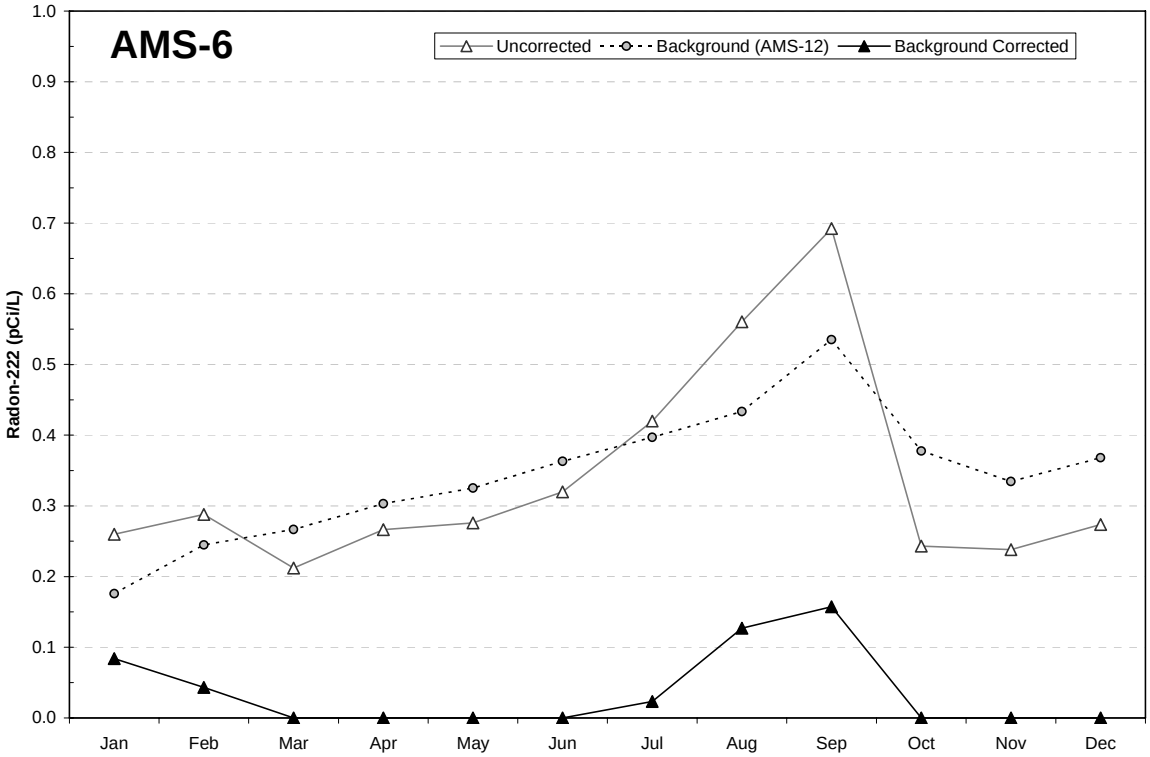

Figure C.2−5 2007 Monthly Average Concentration for Facility Boundary

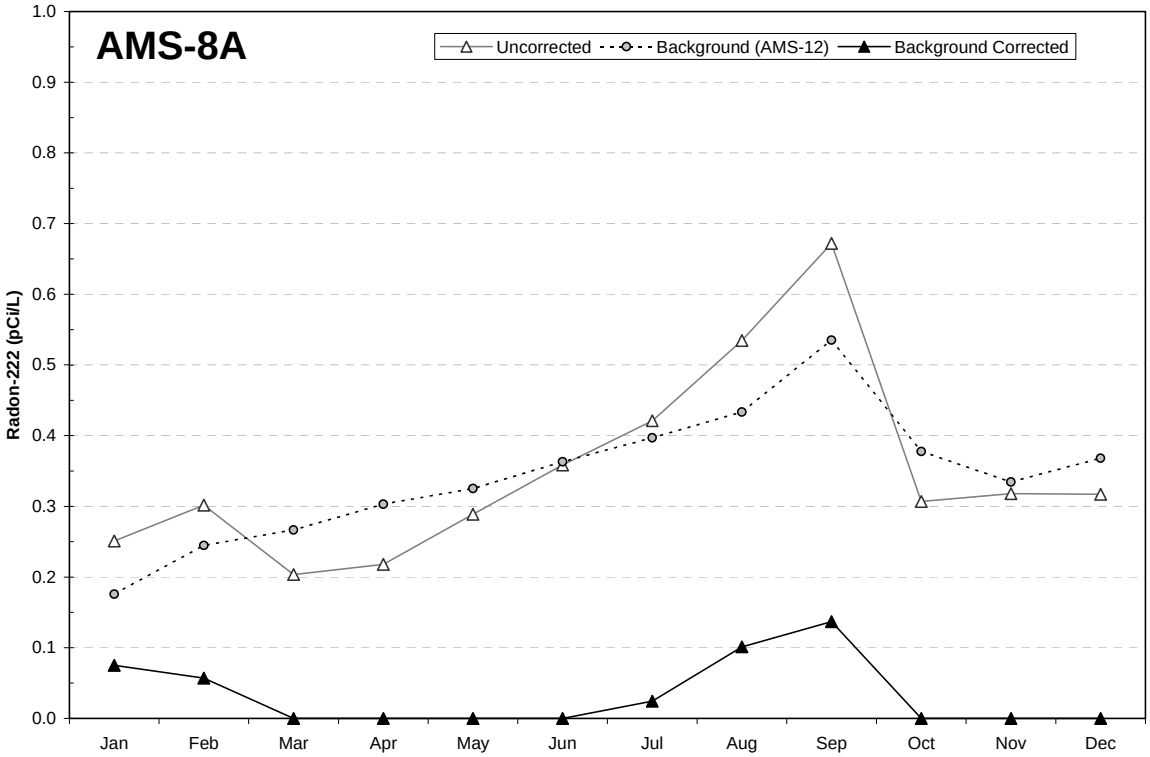

Figure C.2−6 2007 Monthly Average Concentration for Facility Boundary Monitor

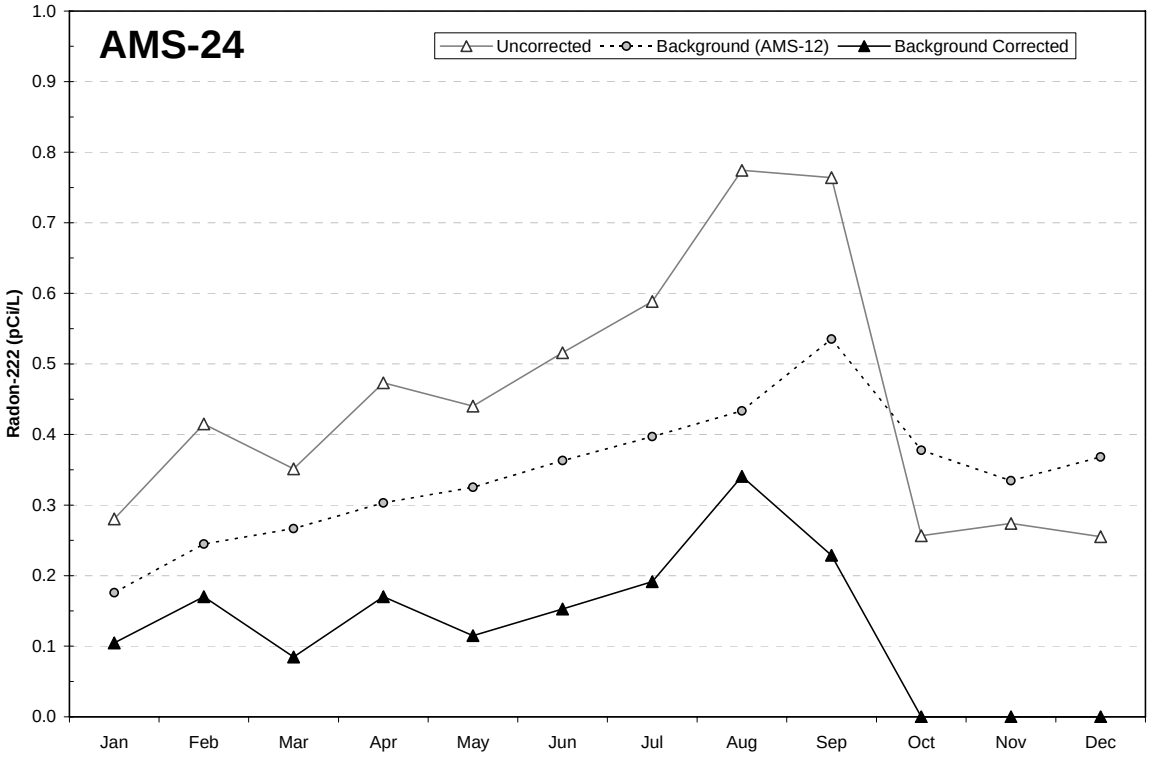

Figure C.2−7 2007 Monthly Average Concentration for Facility Boundary Monitor

Attachment C.3

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C3.0 Direct Radiation

Direct radiation measurements were collected at six monitoring locations using thermoluminescent dosimeters (TLDs). Five of the TLDs are located along the Fernald Preserve boundary (2, 3, 6, 8A and 35) and one is placed at the background station (27) northwest of the site (Figure C.3−1). Three TLDs are deployed at each location to track and evaluate direct radiation, and each TLD is collected and measured on a quarterly basis (approximately every 91 days). As noted for the particulate monitoring stations (Attachment C.1), completion of soil remediation and construction activities in 2006 resulted in a reduction of monitoring locations.

Table C.3−1 provides a summary of the average dose for 2007, 2006 and 2005. Although the data from stations 2, 3, 6, 8A, 27 and 35 show a decrease in the direct radiation measurements from 2005 to 2007, this trend is not attributed to the removal of contaminate sources at the Fernald Preserve. Rather, the decrease is a result of using different TLD crystals and laboratories to capture and count the direct radiation dose.

In 2005, direct radiation dose was calculated using the average value from TLD elements 2, 3 and 4. Using element 2 to calculate the average dose was incorrect, as element 2 is a lithium borate crystal and elements 3 and 4 are calcium sulfate crystals. The lithium borate element estimates skin dose, while the calcium sulfate crystals measure deeper tissue dose. At the Fernald Preserve, the deep tissue is the target of concern. As the dose readings on the lithium borate crystal are high relative to the calcium sulfate crystal, adding the skin dose to the deep tissue dose in the 2005 assessment biased the annual deep-tissue dose to high values. For 2006, the measurement recorded by the lithium borate crystal was removed from the calculation of deep tissue dose, and the 2006 results reflect the unbiased dose estimate to deep tissue.

A change in the TLD vendor was made in early 2007, and the quarterly results for 2007 reflect the distribution, collection and counting of the TLDs by a new vendor. Calcium sulfate crystals are used in the present TLDs to capture the radiation attributed to deep tissue dose. Therefore, the crystal used to capture the radiation dose is similar to that used in 2006, yet the 2007 direct radiation measurements at the boundary and background locations are about one-half of those collected in 2006. As the 2007 background radiation counts have dropped by approximately the same percentage as the boundary counts, relative to the 2006 data, the decrease in the 2007 values cannot be attributed to the completion of soil remediation and demolition activities in 2006. The difference in the 2006 and 2007 values is most likely due to variation in the counting geometry and equipment used by the vendors.

Quantification of the direct radiation dose delivered to an individual at the Fernald Preserve boundary is presented in Appendix D, and there is no significant dose associated with direct radiation at the Fernald Preserve boundary. This is in line with Figure C.3−2, which shows that the 95 percent confidence interval of the mean for the quarterly values overlaps for boundary and background (location 27) monitors. Moreover, the Fernald Preserve no longer has open waste disposal areas to serve as surface sources for direct radiation. Given the lack of sources and statistically similar boundary and background values, it is reasonable to question whether future TLD measurements will provide meaningful data.

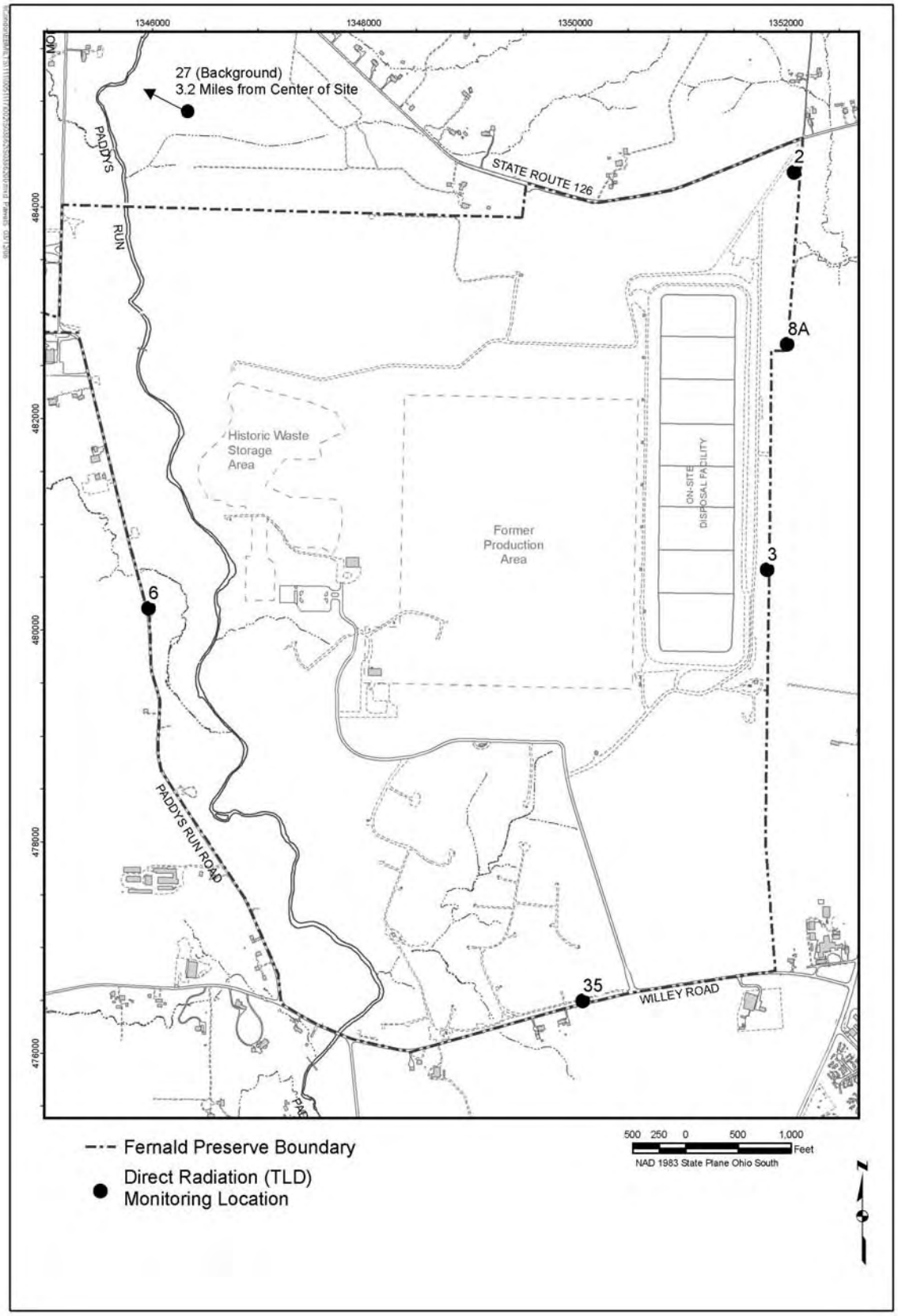

Figure C.3−1. Direct Radiation (Thermoluminescent Dosimeter) Monitoring Locations

Table C.3−1. Direct Radiation (TLD) Measurements

	Direct Radiation Summary Results (mrem)		
Location	2007[a]	2006[b,c]	2005
Boundary			
2	52	83	101
3	49	83	102
6	49	79	96
8A	53	84	98
35	47	80	94
Minimum	**47**	**79**	**94**
Maximum	**53**	**84**	**102**
Background			
27	48	79	93

[a] 2007 values are lower than 2006 because the 2007 TLDs, comprised of calcium sulfate crystals, were issued and counted by a new vendor.

[b] 2006 max values are lower than 2005 because 2005 included TLD results from element 2. Element 2 is a lithium borate crystal, and 2005 data from this detector should not have been averaged with elements 3 and 4, which are calcium sulfate crystals.

[c] The minimum and maximum results presented for 2006 are based only on those TLDs that were in service throughout 2007 (i.e. 2, 3, 6, 8A, 35, and 27).

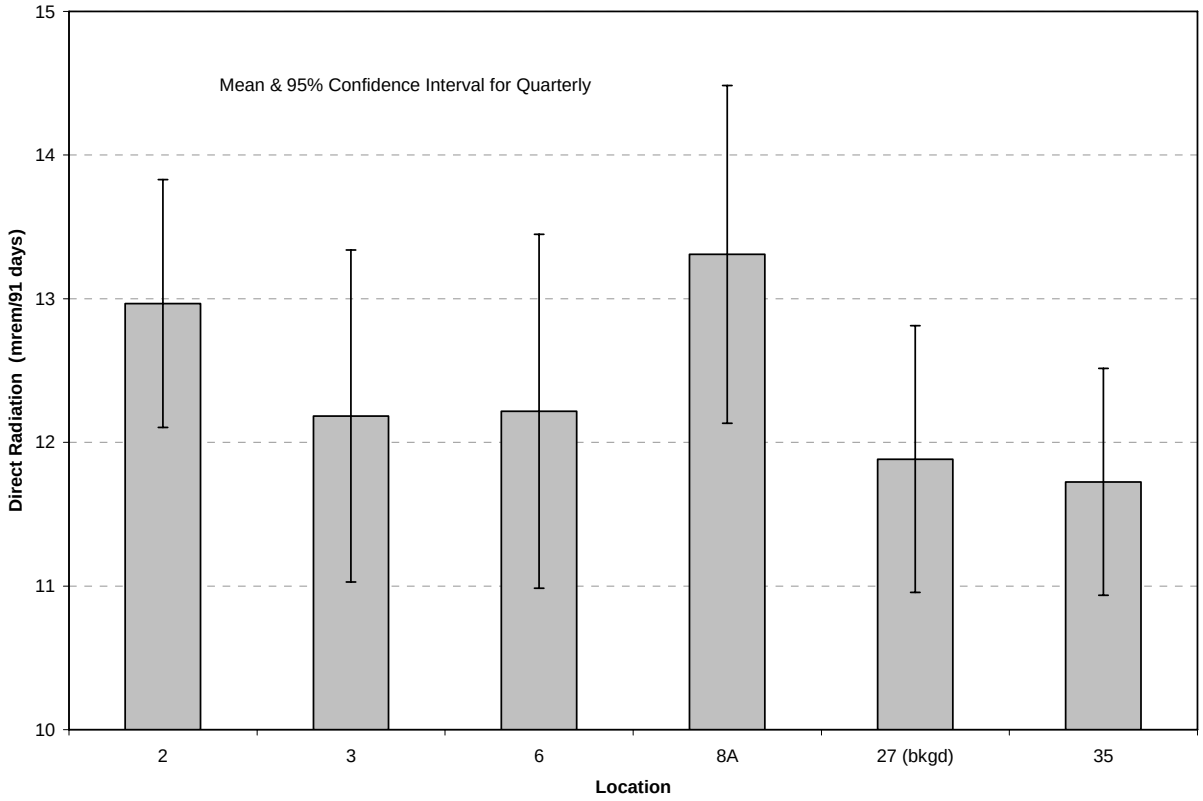

Figure C.3−2. 2007 Mean and 95% Confidence Interval for Quarterly Measurements

Attachment C.4

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C.4.0 Meteorological Data

Meteorological data were collected at the Fernald site's meteorological station through May 16, 2006, when the station was shut down. As meteorological data were not collected at the Fernald Preserve in 2007, two sources were used to obtain the data used in the 2007 dose assessment. Temperature and precipitation data were obtained from the Butler County Airport. Wind velocity and direction data were obtained by averaging the wind data collected at the former site meteorological station over the period 2002 through 2006, as these parameters are sensitive to vegetative cover and topography and play a key role in predicting how pollutants are distributed in the surrounding environment.

Wind speed data from the 10-meter and 60-meter elevations (Table C.4−1) are summarized as monthly maximum and minimum, with the largest range occurring in March (42 and 0.3 mph at 10-meter; 52 and 0.4 mph at 60-meter). Ambient air temperature at the 10-meter level includes monthly average, maximum and minimum. As expected for the northern hemisphere, the yearly maximum temperatures occur from May through August, with minimums observed in January and February. Historically precipitation information indicates that April and May are the wettest months; however, due to the drought conditions in 2007, May and October were the wettest months of 2007.

Table C.4−2 indicates the prevailing winds are from the southwest quadrant (WSW, SW and SSW) about 39 percent of the time at the 10-meter height and about 35 percent of the time for the 60-meter height. Winds out of the north and east quadrants are the least frequent. Average wind speed varies from 3 to 7 mph at the 10-meter height and 5 to 10 mph at the 60-meter height.

Although meteorological data were not collected in 2007, it is assumed that the 5-yr values for wind speeds and directions are representative of conditions at the Fernald Preserve, and the information in Table C.4−2 was used for the dose assessment presented in Attachment C.5.

Table C.4−1. Meteorological Data

	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10-Meter Wind Velocity[a]													
Maximum	mph	32	37	42	36	34	27	37	31	28	30	33	31
(hourly average)	kph	51	59	67	57	54	44	59	49	44	48	52	49
Minimum	mph	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.2
(hourly average)	kph	0.5	0.4	0.5	0.5	0.4	0.5	0.5	0.4	0.4	0.4	0.4	0.4
60-Meter Wind Velocity[a]													
Maximum	mph	44	49	52	47	41	35	48	35	42	40	45	42
(hourly average)	kph	70	78	82	75	66	55	77	57	67	65	72	68
Minimum	mph	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.3	0.2	0.2	0.4	0.2
(hourly average)	kph	0.6	0.4	0.7	0.7	0.6	0.6	0.6	0.4	0.4	0.4	0.7	0.4
Ambient Air Temperature[b]													
Average	°F	28	21	49	52	80	74	73	79	70	61	44	36
	°C	-2	-6	10	11	27	23	23	26	21	16	6	2
Maximum	°F	35	31	61	63	90	87	85	93	86	73	55	44
	°C	2	0	16	17	32	30	30	34	30	23	13	7
Minimum	°F	22	10	38	40	61	62	60	65	55	49	32	28
	°C	-6	-12	3	4	16	17	16	18	13	9	0	-2
Precipitation[b]													
Total	in	4.1	3.3	2.7	4.0	0.8	4.3	2.6	1.2	1.9	5.5	2.5	4.7
	cm	10.4	8.5	6.8	10.3	1.9	10.9	6.7	3.0	4.8	13.9	6.3	12.0
Daily Maximum	in	0.9	0.7	0.6	1.4	0.3	1.2	0.9	0.6	0.7	1.9	1.1	0.8
	cm	2.2	1.7	1.5	3.5	0.6	3.1	2.3	1.4	1.7	4.7	2.7	2.1

[a]Wind-velocity data were not collected at the Fernald Preserve in 2007. Values represent 5-yr average for site data collected from 2002 through mid-2006.
[b]Data obtained from Butler County Airport, Ohio.

*Table C.4−2. 2007 Average Wind Speed and Percent of Time from Direction at 10 and 60 Meters Above Ground Level**

Direction	Average 10-meter Wind Speed (mph)	(kph)	Percent of Time from Direction[b]	Average 60-meter Wind Speed (mph)	(kph)	Percent of Time from Direction[b]
N	6	10	1.5	9	14	1.5
NNE	7	11	2.7	10	16	3.7
NE	6	9	5.4	8	13	8.0
ENE	5	8	6.7	7	11	8.3
E	4	6	4.0	6	10	4.3
ESE	3	5	2.9	5	9	2.7
SE	3	5	3.3	6	9	3.2
SSE	3	6	4.1	7	11	3.8
S	5	7	6.8	9	14	7.4
SSW	6	10	13.0	10	16	13.1
SW	5	8	14.8	9	15	11.9
WSW	4	6	11.1	10	15	9.6
W	4	7	9.3	10	15	7.9
WNW	5	8	6.9	10	15	5.9
NW	6	9	5.4	10	15	5.5
NNW	7	12	2.4	10	16	3.2

[a] Wind-velocity data were not collected at the Fernald Preserve in 2007.
Values represent 5-yr average for site data collected from 2002 through mid-2006.

[b] Percent of time wind is blowing from the indicated direction.

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Attachment C.5

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C.5.0 Supplemental Dose Assessments

This attachment contains a detailed discussion of the supplemental dose assessments performed for calendar year 2007, and compares the 2007 results to those from 1999 through 2006. The population and biota dose assessments comprise the supplemental dose assessment, which provides required information for compliance with the DOE standards contained in DOE Order 5400.5 (DOE 1993).

A population dose assessment provides an aggregate measure of the impact of airborne emissions and direct radiation from sources at the Fernald Preserve to the population in the area. However, with the completion of soil remediation and capping of the final OSDF cells in 2006, the only remaining source for airborne emissions and direct radiation is the soil. As the soil has been certified to contain contaminant levels at or near background values, there is no remaining source to deliver a statistically significant dose to the public. The population dose assessment presented below supports this conclusion.

The groundwater remediation program continues to discharge large volumes of water to the Great Miami River, and the biota dose assessment provides information on the Fernald Preserve's compliance with dose limits to aquatic organisms in the Great Miami River.

C.5.1 Population Dose Assessment

Computation of a population dose is a requirement of DOE Order 5400.5, which defines population dose as the collective effective dose equivalent. Collective effective dose is the dose spread across the population within a 50 mile radius of the site. For 2007, the effective dose equivalent was 0.025 person-rem/yr. This includes 0.010 person-rem/yr from site airborne emissions (excluding radon) and 0.015 person-rem/yr from the direct radiation component (Table C.5−1). There was no estimated biota dose to the population from consumption of produce, as the produce monitoring program was completed in 2003.

Table C.5−1. Estimated Population Doses (person-rem)

	1999[a]	2000	2001[a]	2002[a]	2003	2004[a]	2005[a]	2006[a]	2007[a]
Air Inhalation	1.19	3.29	3.35	3.47	3.84	3.87	1.2	0.485	0.010
Direct radiation	0.127	0.108	0.159	0.23	0.155	0.47	0.35	0.030	0.015
Biota[b]	NA	0.48	NA	NA	0.002	NA	NA	NA	NA
Total	**1.317**	**3.88**	**3.51**	**3.70**	**4.00**	**4.34**	**1.55**	**0.515**	**0.025**

na = not applicable.

[b]Produce for biota dose was sampled every three years, and program was completed in 2003.

The air inhalation dose component was estimated by using the 1990 census information for the population within 50 miles of the site, as distributed between four equally sized quadrants (NE, SE, SW, NW). In 2007, monitoring was performed at only five of the 16 boundary locations per EPA approval (DOE 2006a and 2006b), and the data are not uniformly distributed between four equal quadrants. Therefore, the net concentration above background for each of the five locations was summed and averaged to obtain an estimate of the net concentration at the 11 stations that

lacked 2007 data. A dose was estimated for each population quadrant based on the net air concentration at each boundary monitor, the population at varying distances from the site, and the dose conversion factors. The following conservative assumptions are used in the calculations:

- Inhalation rate of 1.2 cubic meters (m^3) per hour for 8,760 hours per year (ICRP 1975)
- Population distribution in area (DOE 1997)
- Wind rose data (refer to Appendix D, Figure D−2 of this report)
- Average net concentrations are applied out to a distance of three miles from the site boundary (the nearest site background monitor). For populations beyond three miles, the average net concentration is diluted as the inverse square of the distance ($1/d^2$) from the boundary to account for dispersion of the site-generated particulate (e.g., between 3 and 4 miles from the boundary, the dose calculation uses the average net concentration divided by 9).
- Inhalation dose conversion factors (DOE 1988).

The direct radiation dose component was estimated by using the population distribution within 50 miles of the site, as distributed between 16 equally sized compass sectors (N, NNE, NE, ENE, etc). In 2007, monitoring was performed at only five of the 16 boundary locations per EPA approval (DOE 2006a and 2006b) and the TLD data are not uniformily distributed between four equal quadrants. Therefore, an estimate of the direct radiation at the unmonitored 11 locations is needed to evaluate the direct radiation dose. The 95 percent confidence interval of the mean for quarterly measurements at the boundary and background locations overlap (Attachment C.3). This implies that direct radiation at the site boundary is not significantly different from background, and the background value was used at the 11 locations that had no data. A dose was estimated for each population sector based on the direct radiation level that exceeded background at the site boundary and the distance between the location of the population and the major source of past radiation at the Fernald Preserve (e.g., silos project area). The following conservative assumptions were used in the calculations:

- Population lives 8,760 hours per year in area (DOE 1997)
- The number of people per household is estimated by total population per sector per mile divided by number of households per sector per mile
- The net direct radiation levels are calculated from boundary TLD results minus the background result, with no correction for analytical uncertainty

The decrease in the collective effective population dose from 2006 to 2007 reflects the completion of remedial actions for the soil, waste pits and OSDF project areas in 2006, which resulted in lower radionuclide concentrations in particulate samples. As discussed in Attachment C.3, the direct radiation dose has been at or near background for the past several years. The very low direct radiation dose reported for the past several years is a result of using analytical measurements without considering the error on the measurement and the statistical similarity of background and boundary values. If measurement error and statistical variability were evaluated for all TLD measurements, all boundary readings would be indistinguishable from background, and the direct radiation dose would be zero.

Air inhalation is the only realistic component of the collective population dose, because particulate emissions from the Fernald Preserve may contain radionuclides that slightly exceed

the background values. However, the total collective population doses attributed to remedial actions at the Fernald Preserve, over the years 1999 through 2007 (Table C.5−1), are very low relative to background dose values. The background radiation dose, from the sun and naturally occurring radionuclides in food products and the earth, is estimated to be 300,000 person-rem for the population within 50 miles of the Fernald Preserve. A review of the 2007 estimated dose in Table C.5−1 shows it is 10 million times less than background dose, which implies it is an insignificant dose in terms of compliance with NESHAP requirements (Appendix D).

C.5.2 Biota Dose Assessment

DOE Order 5400.5 requires that populations of aquatic biota be protected at a dose limit of 1 rad/day. The DOE has issued a technical standard entitled, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (DOE 2002), and supporting software (RAD-BCG) for use in the evaluation and reporting of biota dose limits. A biota dose assessment divides the radionulcide concentrations in surface water and/or sediment samples to pre-established biota concentration guides (BCGs) for specific radionuclides and sums the fractions for each radionuclide. If the resulting sum of fractions is less than 1.0, compliance with the biota dose limit is assured. BCGs have been established for radionuclides that are relatively common constituents in past radionuclide releases to the environment from DOE facilities. For the isotopes at the Fernald Preserve, the radium isototpes have the lowest BCG values, hence they account for most of the weight in the sum of fractions presented here.

For 1999 through 2005, the Fernald site determined compliance with the biota dose limit to aquatic biota using the RAD-BCG code and the diluted (i.e., mixed) concentration for each applicable radionuclide discharged to the Great Miami River at the Parshall Flume. Although the Parshall Flume was the only discharge point evaluated through 2005, two discharge points (Paddys Run and the Parshall Flume) are delivering mass to the Great Miami River. Beginning in 2006, both discharge points were evaluated to calculate the dose ot aquatic biota in the Greate Miami River.

In 2003, OEPA published a fact sheet that provided the harmonic mean flow for Paddys Run (0.19 cfs; OEPA 2003), allowing this discharge point to be evaluated in addition to the Parshall Flume. Therefore, the biota assessments for 2003 through 2007 were performed using the mass delivered from both discharge points to determine the annual average mixing concentration in the Great Miami River. Note that these assessments only evaluate the contaminant contribution from the Fernald Preserve (i.e., the contribution that is above background).

The maximum measured concentration for each radionuclide at the Parshall Flume (PF-4001) and Paddys Run (SWP-03) monitoring locations was multiplied by the annual volume of water discharged to the Great Miami River at the Parshall Flume and Paddys Run to obtain an estimate of the maximum mass of each radionuclide delivered to the river at each discharge point (e.g., pCi/L * L = total pCi). For each radionuclide, the mass discharged at the Parshall Flume was added to the mass discharged at Paddys Run to obtain the annual total mass delivered to the river. The annual total mass delivered to the river was divided by the annual total volume of mixed water (Parshall Flume + Paddys Run + Great Miami River) to obtain the annual radionuclide concentrations used in the RAD-BCG model for the biota dose assessment (as noted above, this concentration represents the concentration above background).

Table C.5−2 contains a summary of the output from the RAD-BCG computer model for 1999 through 2007, showing results for one discharge point (Parshall Flume 1999 through 2005) and two discharge points (Parshall Flume and Paddys Run 2003 through 2007). Results for 2007 show the sum of fractions (0.009) is well below the compliance threshold value of 1.0. The decrease in 2007 is due primarily to the decrease in radium discharged at the Parshall Flume.

Table C.5−2. Estimated Sum-of-the-Fractions for Biota Dose*

	1999[b]	2000[b]	2001[b]	2002[b]	2003	2004	2005	2006[b]	2007[b]
PF	0.015	0.035	0.038	0.023	0.035	0.059	0.017	NA	NA
PR & PF	NA	NA	NA	NA	0.035	0.059	0.005	0.062	0.009

Note: PF = 1999 through 2005 calculated using one discharge point (Parshall Flume [PF])
PR & PF = 2003 through 2007 calculated using two discharge points (Paddys Run [PR] and Parshall Flume [PF])

[a] Sum-of-the-fractions calculated with the RAD-BCG code.

[b] NA = not applicable.

Recalculated results for 2003 and 2004, for two discharge points, are identical to the initial results calculated for one discharge point. This indicates that the mass delivered from Paddys Run is insignificant relative to the mass delivered at the Parshall Flume. When the contaminant concentration is similar at the two discharge points, the contaminant mass delivered to the Great Miami River from Paddys Run will be much less than the mass deliverd to the river at the Parshall Flume because of the large difference in discharge volume. Based on the harmonic mean flow for Paddys Run (0.19 cfs; OEPA 2003), the annual volume of water discharged to the Great Miami River is 1.70E+08 L, compared to 2.34E+09 L for the 2007 Parshall Flume data.

C.5.3 References

DOE (U.S. Department of Energy), 1988, "Internal Dose-Rate Conversion Factors for Calculation of Dose to the Public," DOE/EH-0071, Washington, D.C., July.

DOE (U.S. Department of Energy), 1993, "Radiation Protection of the Public and the Environment," DOE Order 5400.5, Change 2, Washington, D.C., January.

DOE (U.S. Department of Energy), 1997, "1996 Site Environmental Report," DE-A24-92OR21972, Fluor Fernald, DOE, Fernald Area Office, Cincinnati, OH, June.

DOE (U.S. Department of Energy), 2002, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota," Final Technical Standard, Project No. ENVR-0011, Washington, D.C.

DOE (U.S. Department of Energy), 2006a. "Approval for removing Phase 1 – TLD, Radon and Particulate Monitors (AMS-04, AMS-05, AMS-07, AMS-23, AMS-25 and AMS-28)," received at weekly conference call on 11 April 2006.

DOE (U.S. Department of Energy), 2006b. “Phase II Site Boundary Air Monitor Reductions,” approval letter received from EPA on November 29, 2006.

International Commission on Radiological Protection (ICRP), 1975, “Reference Man: Anatomical, Physiological, and Metabolic Characteristics,” ICRP Publication 23

Ohio Environmental Protection Agency (OEPA), 2003, NPDES Permit Fact Sheet, Public Notice# 03-04-019, April 7, 2003

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